Life and Quantum Research Literatures

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Abstract: Life is a characteristic that distinguishes physical entities that do have biological processes, such as signaling and self-sustaining processes, from those that do not, either because such functions have ceased, or because they never had such functions and are classified as inanimate. Various forms of life exist, such as plants, animals, fungi, protists, archaea, and bacteria. The criteria can at times be ambiguous and may or may not define viruses, viroids, or potential artificial life as living. Biology is the primary science concerned with the study of life, although many other sciences are involved. In physics, a quantum is the minimum amount of any physical entity involved in an interaction. The fundamental notion that a physical property may be "quantized" is referred to as "the hypothesis of quantization. This means that the magnitude of the physical property can take on only discrete values consisting of integer multiples of one quantum.
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Life is a characteristic that distinguishes physical entities that do have biological processes, such as signaling and self-sustaining processes, from those that do not, either because such functions have ceased, or because they never had such functions and are classified as inanimate. Various forms of life exist, such as plants, animals, fungi, protists, archaea, and bacteria. The criteria can at times be ambiguous and may or may not define viruses, viroids, or potential artificial life as living. Biology is the primary science concerned with the study of life, although many other sciences are involved. In physics, a quantum is the minimum amount of any physical entity involved in an interaction. The fundamental notion that a physical property may be "quantized" is referred to as "the hypothesis of quantization. This means that the magnitude of the physical property can take on only discrete values consisting of integer multiples of one quantum.

The following introduces recent reports as references in the related studies.

Ahmed, M. S., et al. (2016). "Health-related quality of life of chronic obstructive pulmonary disease patients: Results from a community based cross-sectional study in Aligarh, Uttar Pradesh, India." Lung India **33**(2): 148-153.

BACKGROUND: Chronic obstructive pulmonary disease (COPD) is characterized by airflow limitation that is not fully reversible. It is an incurable disease with improvement in quality of life (QOL) as a major focus area for management. This study assesses the QOL of COPD patients and the factors affecting it. MATERIALS AND METHODS: All 124 patients diagnosed with COPD in a larger cross-sectional study to determine the prevalence of COPD were assessed for their QOL using St. George's respiratory questionnaire for COPD patients (SGRQ-C). Spirometry was performed to assess lung function and diagnose COPD. Chronic lung disease (CLD) severity index was used to assess the severity of symptoms and the Medical Research Council questionnaire was used to assess the severity of dyspnea. Sociodemographic data regarding the patients were also recorded. RESULTS: Patients with COPD showed significantly reduced health-related quality of life (HRQOL). CLD estimate for severity of lung disease and the Medical Research Council assessment for dyspnea and the duration of illness showed a highly significant positive correlation with HRQOL. There was a statistically significant negative correlation between lung function and SGRQ-C score. Increasing age, increased quantum of smoking, and lower socioeconomic status were correlated with poorer HRQOL. No association between QOL and education, body mass index (BMI), and gender was observed. CONCLUSION: This study showed that Indian patients with COPD had reduced HRQOL. Poor lung function, increased disease duration and smoking, and worsening symptoms impacted HRQOL negatively.

Alvarez-Rodriguez, U., et al. (2016). "Artificial Life in Quantum Technologies." Sci Rep **6**: 20956.

We develop a quantum information protocol that models the biological behaviours of individuals living in a natural selection scenario. The artificially engineered evolution of the quantum living units shows the fundamental features of life in a common environment, such as self-replication, mutation, interaction of individuals, and death. We propose how to mimic these bio-inspired features in a quantum-

mechanical formalism, which allows for an experimental implementation achievable with current quantum platforms. This study paves the way for the realization of artificial life and embodied evolution with quantum technologies.

Andrulis, E. D. (2011). "Theory of the origin, evolution, and nature of life." Life (Basel) **2**(1): 1-105.

Life is an inordinately complex unsolved puzzle. Despite significant theoretical progress, experimental anomalies, paradoxes, and enigmas have revealed paradigmatic limitations. Thus, the advancement of scientific understanding requires new models that resolve fundamental problems. Here, I present a theoretical framework that economically fits evidence accumulated from examinations of life. This theory is based upon a straightforward and non-mathematical core model and proposes unique yet empirically consistent explanations for major phenomena including, but not limited to, quantum gravity, phase transitions of water, why living systems are predominantly CHNOPS (carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur), homochirality of sugars and amino acids, homeoviscous adaptation, triplet code, and DNA mutations. The theoretical framework unifies the macrocosmic and microcosmic realms, validates predicted laws of nature, and solves the puzzle of the origin and evolution of cellular life in the universe.

Arapkina, L. V. and V. A. Yuryev (2011). "CMOS-compatible dense arrays of Ge quantum dots on the Si (001) surface: hut cluster nucleation, atomic structure and array life cycle during UHV MBE growth." Nanoscale Res Lett **6**(1): 345.

We report a direct observation of Ge hut nucleation on Si (001) during UHV molecular beam epitaxy at 360 degrees C. Nuclei of pyramids and wedges were observed on the wetting layer (WL) (M x N) patches starting from the coverage of 5.1 A and found to have different structures. Atomic models of nuclei of both hut species have been built as well as models of the growing clusters. The growth of huts of each species has been demonstrated to follow generic scenarios. The formation of the second atomic layer of a wedge results in rearrangement of its first layer. Its ridge structure does not repeat the nucleus. A pyramid grows without phase transitions. A structure of its vertex copies the nucleus. Transitions between hut species turned out to be impossible. The wedges contain point defects in the upper corners of the triangular faces and have preferential growth directions along the ridges. The derived structure of the {105} facet follows the paired dimer model. Further growth of hut arrays results in domination of wedges, and the density of pyramids exponentially drops. The second generation of huts arises at coverages >10 A; new huts occupy the whole WL at coverages ~14 A. Nanocrystalline Ge 2D layer begins forming at coverages >14 A.

Axelsson, S. (2003). "Perspectives on handedness, life and physics." Med Hypotheses **61**(2): 267-274.

In contrast to motion, matter will be conserved in all eternity. Structure and function will arise by the angular momentum of spinning spherical particles and their composites. Symmetry prevails in physics by equal amounts of left- and right-hand spinning entities, while life is asymmetric in this respect. Very rare deviations from the ubiquitous one-sided handedness in biology will probably explain the inert degradation resistant proteins in 'mad cow' type diseases. Velocities of physical events seems to be a most important feature and will explain for instance brain function and the true nature of neurodegenerative diseases. This biophysics of mind will in turn provide answers to many disputable aspects of physics such as the true nature of waves and gravity. Many current concepts in quantum physics will be invalidated, among them the uncertainty principle, the relativity to a fixed speed of light, the energy equation and the expansion of the Universe. Instead, decay and formation will balance each other in a continuum of matter in an intuitively cyclic Multiverse.

Balazs, A. (2003). "On the physics of the symbol--matter problem in biological systems and the origin of life: affine Hilbert spaces model of the robustness of the internal quantum dynamics of biological systems." Biosystems **70**(1): 43-54.

In the present paper, some physical considerations of the biological symbol-matter problem is exposed. First of all, the physical concept of quantum dynamical internal measuremental robustness is discussed. In this context, the significance of introducing affine molecular Hilbert spaces, the original (primordeal) internal quantum measurement, and the global constraining nature of time-inversion symmetry restoring, as a special restoration force, is discussed at some length. It is pointed out, as a summary, that global robustness of the internal dynamics of quantum measurements is due to two basic factors: on one hand, the global constraining nature of the chosen specific (symmetry-) restoring force, and on the other, the individual robustness of the discrete local internal measuremental interactions. The second condition is supposed to follow from a system-internalised ("objective") Bohr-type Copenhagen interpretation of quantum mechanics, corresponding, in an external context, to the Generalized Complementarity Principle of Bohr

and Elsasser. It is not claimed, however, that this latter problem has been, as yet, satisfactorily settled physically. In fact, if it were, it would amount to a specifically biological quantum theory of internal measurement, which had to be rooted in the original primordeal global internal measurement, amounting to the origin of the genetic code.

Balazs, A. (2006). "Some introductory formalizations on the affine Hilbert spaces model of the origin of life. I. On quantum mechanical measurement and the origin of the genetic code: a general physical framework theory." Biosystems **85**(2): 114-125.

A physical (affine Hilbert spaces) frame is developed for the discussion of the interdependence of the problem of the origin (symbolic assignment) of the genetic code and a possible endophysical (a kind of "internal") quantum measurement in an explicite way, following the general considerations of Balazs (Balazs, A., 2003. BioSystems 70, 43-54; Balazs, A., 2004a. BioSystems 73, 1-11). Using the Everett (a dynamic) interpretation of quantum mechanics, both the individual code assignment and the concatenated linear symbolism is discussed. It is concluded that there arises a skewed quantal probability field, with a natural dynamic non-linearity in codon assignment within the physical model adopted (essentially corresponding to a much discussed biochemical frame of self-catalyzed binding (charging) of t RNA like proto RNAs (ribozymes) with amino acids). This dynamic specific molecular complex assumption of individual code assignment, and the divergence of the code in relation to symbol concatenation, are discussed: our frame supports the former and interpret the latter as single-type codon (triplet), also unambiguous and extended assignment, selection in molecular evolution, corresponding to converging towards the fixedpoint of the internal dynamics of measurement, either in a protein- or RNA-world. In this respect, the general physical consequence is the introduction of a fourth rank semidiagonal energy tensor (see also Part II) ruling the internal dynamics as a non-linear in principle second-order one. It is inferred, as a summary, that if the problem under discussion could be expressed by the concepts of the Copenhagen interpretation of quantum mechanics in some yet not quite specified way, the matter would be particularly interesting with respect to both the origin of life and quantum mechanics, as a dynamically supported natural measurement-theoretical split between matter ("hardware") and (internal) symbolism ("software") aspects of living matter.

Bera, P. P., et al. (2016). "Mechanisms for the formation of thymine under astrophysical conditions and implications for the origin of life." J Chem Phys **144**(14): 144308.

Nucleobases are the carriers of the genetic information in ribonucleic acid and deoxyribonucleic acid (DNA) for all life on Earth. Their presence in meteorites clearly indicates that compounds of biological importance can form via non-biological processes in extraterrestrial environments. Recent experimental studies have shown that the pyrimidine-based nucleobases uracil and cytosine can be easily formed from the ultraviolet irradiation of pyrimidine in H2O-rich ice mixtures that simulate astrophysical processes. In contrast, thymine, which is found only in DNA, is more difficult to form under the same experimental conditions, as its formation usually requires a higher photon dose. Earlier quantum chemical studies confirmed that the reaction pathways were favorable provided that several H2O molecules surrounded the reactants. However, the present quantum chemical study shows that the formation of thymine is limited because of the inefficiency of the methylation of pyrimidine and its oxidized derivatives in an H2O ice, as supported by the laboratory studies. Our results constrain the formation of thymine in astrophysical environments and thus the inventory of organic molecules delivered to the early Earth and have implications for the role of thymine and DNA in the origin of life.

Boiteau, L. and R. Pascal (2011). "Energy sources, self-organization, and the origin of life." Orig Life Evol Biosph **41**(1): 23-33.

The emergence and early developments of life are considered from the point of view that contingent events that inevitably marked evolution were accompanied by deterministic driving forces governing the selection between different alternatives. Accordingly, potential energy sources are considered for their propensity to induce self-organization within the scope of the chemical approach to the origin of life. Requirements in terms of quality of energy locate thermal or photochemical activation in the atmosphere as highly likely processes for the formation of activated low-molecular weight organic compounds prone to induce biomolecular self-organization through their ability to deliver quanta of energy matching the needs of early biochemical pathways or the reproduction of self-replicating entities. These lines of reasoning suggest the existence of a direct connection between the free energy content of intermediates of early pathways and the quanta of energy delivered by available sources of energy.

Booth, G. H., et al. (2009). "Fermion Monte Carlo without fixed nodes: a game of life, death, and

annihilation in Slater determinant space." J Chem Phys **131**(5): 054106.

We have developed a new quantum Monte Carlo method for the simulation of correlated many-electron systems in full configuration-interaction (Slater determinant) spaces. The new method is a population dynamics of a set of walkers, and is designed to simulate the underlying imaginary-time Schrodinger equation of the interacting Hamiltonian. The walkers (which carry a positive or negative sign) inhabit Slater determinant space, and evolve according to a simple set of rules which include spawning, death and annihilation processes. We show that this method is capable of converging onto the full configuration-interaction (FCI) energy and wave function of the problem, without any a priori information regarding the nodal structure of the wave function being provided. Walker annihilation is shown to play a key role. The pattern of walker growth exhibits a characteristic plateau once a critical (system-dependent) number of walkers has been reached. At this point, the correlation energy can be measured using two independent methods--a projection formula and a energy shift; agreement between these provides a strong measure of confidence in the accuracy of the computed correlation energies. We have verified the method by performing calculations on systems for which FCI calculations already exist. In addition, we report on a number of new systems, including CO, O (2), CH (4), and NaH--with FCI spaces ranging from 10(9) to 10(14), whose FCI energies we compute using modest computational resources.

Bornet, A., et al. (2010). "Life-times of long-lived coherences under different motional regimes." J Magn Reson **206**(1): 154-156.

The transverse relaxation rate R (2) of single quantum coherences, the relaxation rate R (LLC) of long-lived coherences (LLC), and the ratio R (2)/R (LLC) have been studied by experiment, simulation and theory in the two-spin system formed by the Glycine aliphatic protons of the dipeptide Alanine-Glycine as a function of the correlation time of rotational diffusion.

Borowska, Z. and D. Mauzerall (1988). "Photoreduction of carbon dioxide by aqueous ferrous ion: An alternative to the strongly reducing atmosphere for the chemical origin of life." Proc Natl Acad Sci U S A **85**(18): 6577-6580.

We have shown that ferrous ion at neutral pH photoreduces water to hydrogen with a high quantum yield on excitation with near-ultraviolet light. This simple system also efficiently reduces carbon dioxide (bicarbonate ions) to formaldehyde. Overall, these reactions offer a solution to a dilemma confronting the standard or Oparin-Urey model of the origin of life. If carbon dioxide was the main form of carbon on the primitive earth, the ferrous photoreaction would have provided the reduced carbon necessary to form amino acids and other biogenetic molecules. We believe this system may have been the progenitor to the biological photosynthetic systems.

Burgess, C. P. (2004). "Quantum Gravity in Everyday Life: General Relativity as an Effective Field Theory." Living Rev Relativ **7**(1): 5.

This article is meant as a summary and introduction to the ideas of effective field theory as applied to gravitational systems, ideas which provide the theoretical foundations for the modern use of general relativity as a theory from which precise predictions are possible.

Carroll, A. and M. Barnes (2002). "Life expectancy determination." Phys Med Rehabil Clin N Am **13**(2): 309-322, ix.

The estimate of life expectancy following a personal injury is probably one of the most important factors in determining the final quantum of damages. It is a calculation fraught with difficulties. This article endeavours to outline some general factors that aid prediction of life expectancy, and also discusses the evidence from the few long-term studies currently available.

Chen, L. Q., et al. (2017). "Intensive epidermal adsorption and specific venous deposition of carboxyl quantum dots in zebrafish early-life stages." Chemosphere **184**: 44-52.

To properly assess the environmental risk of quantum dots (QDs), it is necessary to determine their fate in living organisms, including adsorption, distribution and bioaccumulation under representative environmental or physiological conditions. We comprehensively investigated the fate of QDs with carboxyl terminal functional groups (carboxyl-QDs) in zebrafish (Danio rerio) embryo and larvae subjected to either waterborne exposure or cardiovascular system microinjection. On waterborne exposure, carboxyl-QDs exhibited an intensive adsorption and accumulation in the chorion of embryos, and their predominate target organs were the gill and intestinal tract in larvae. On microinjection, carboxyl-QDs were rapidly delivered into the cardiovascular system and specifically deposited in veins and the capillary network system of zebrafish larvae, but not in the arterial system. Taken together, we found that the exact tissue condition including epidermal structures, mucus secretion and vascular microstructures strongly affected the adsorption, uptake and distribution of carboxyl-QDs in zebrafish. This work highlights the

intensive tissue epidermal adsorption and accumulation of carboxyl-QDs and their specific vein and capillary deposition in the cardiovascular system in zebrafish early-life stages.

Conrad, M. (1997). "Origin of life and the underlying physics of the universe." Biosystems **42**(2-3): 177-190.

The thesis is put forward that the non-linear self-organizing dynamics of biological systems are inherent in any physical theory that satisfies the requirements of both quantum mechanics and general relativity. Biological life is viewed as an extension of these underlying dynamics rather than as an emergent property of systems that reached a requisite threshold of complexity at a definite point in time. The underlying dynamics are based on interactions between manifest material organizations and an unmanifest vacuum sea whose density structure is isomorphic to the metric structure of space-time. These interactions possess an intrinsic self-corrective character, due to the fact that quantum processes lead to changes in particle states that have a random aspect, while general relativity requires that the distribution of manifest and unmanifest particles be self-consistent. The model implies vacuum hysteretic effects that would bear on nanobiological phenomena and that might be detected through nanobiological techniques.

Davies, P. C. (2004). "Does quantum mechanics play a non-trivial role in life?" Biosystems **78**(1-3): 69-79.

There have been many claims that quantum mechanics plays a key role in the origin and/or operation of biological organisms, beyond merely providing the basis for the shapes and sizes of biological molecules and their chemical affinities. These range from Schrodinger's suggestion that quantum fluctuations produce mutations, to Hameroff and Penrose's conjecture that quantum coherence in microtubules is linked to consciousness. I review some of these claims in this paper, and discuss the serious problem of decoherence. I advance some further conjectures about quantum information processing in bio-systems. Some possible experiments are suggested.

Deng, W. and E. M. Goldys (2012). "Plasmonic approach to enhanced fluorescence for applications in biotechnology and the life sciences." Langmuir **28**(27): 10152-10163.

One of the most rapidly growing areas of physics and nanotechnology is concerned with plasmonic effects on the nanometer scale; these have applications in sensing and imaging technologies. Nanoplasmonic colloids such as Ag and Au have been attracting active interest, and there has been a recent explosion in the use of these metallic nanostructures to modify the spectral properties of fluorophores favorably and to enhance the fluorescence emission intensity. In this feature article, we summarize our work over a range of nanoplasmonics-assisted biological applications such as flow cytometry, immunoassays, cell imaging and bioassays where we use custom-designed plasmonic nanostructures (Ag and Au) to enhance fluorescence signatures. This fluorophore-metal effect offers unique advantages in providing improved photostability and enhanced fluorescence signals. We discuss the plasmonic enhancement of lanthanide fluorophores whose long and microsecond lifetimes offer the advantage of background-free fluorescence detection, but low photon cycling rates lead to poor brightness. We also show that plasmonic colloids are capable of enhancing the emission of fluorescent nanoparticles, including upconverting nanocrystals and lanthanide nanocomposites.

Domondon, A. T. (2006). "Bringing physics to bear on the phenomenon of life: the divergent positions of Bohr, Delbruck, and Schrodinger." Stud Hist Philos Biol Biomed Sci **37**(3): 433-458.

The received view on the contributions of the physics community to the birth of molecular biology tends to present the physics community as sharing a basic level consensus on how physics should be brought to bear on biology. I argue, however, that a close examination of the views of three leading physicists involved in the birth of molecular biology, Bohr, Delbruck, and Schrodinger, suggests that there existed fundamental disagreements on how physics should be employed to solve problems in biology even within the physics community. In particular, I focus on how these three figures differed sharply in their assessment of the relevance of complementarity, the potential of chemical methods, and the relative importance of classical physics. In addition, I assess and develop Roll-Hansen's attempt to conceptualize this history in terms of models of scientific change advanced by Kuhn and Lakatos. Though neither model is fully successful in explaining the divergence of views among these three physicists, I argue that the extent and quality of difference in their views help elucidate and extend some themes that are left opaque in Kuhn's model.

Drummen, G. P. (2010). "Quantum dots-from synthesis to applications in biomedicine and life sciences." Int J Mol Sci **11**(1): 154-163.

Imagine devices or particles so small that they are invisible to the naked eye. Imagine that such entities could be used to patrol our bodies and autonomously augment endogenous defense and repair

mechanisms. Imagine the defeat of illness at a fraction of the current costs. Bionanotechnology is the field of science that deals with just that: the development of imaging, tracking, targeting, sensing, diagnostic, and eventually therapeutic capabilities based on particles in the nanometer range, i.e., "nanoparticles". Within the extensive group of nanoparticles, semiconducting quantum dots play a central and prominent role. Quantum dots excel at a myriad of physical properties, most notably their fluorescent properties, such as high quantum yield, photo-stability, broad absorption spectra, and their remarkable size-dependent emission-tunability.

Dudley, L. S., et al. (2015). "Seasonal changes in physiological performance in wild Clarkia xantiana populations: Implications for the evolution of a compressed life cycle and self-fertilization." Am J Bot **102**(6): 962-972.

PREMISE OF THE STUDY: One explanation for the evolution of selfing, the drought escape hypothesis, proposes that self-fertilization may evolve under conditions of intensifying seasonal drought as part of a suite of traits that enable plants to accelerate the completion of their life cycle, thereby escaping late-season drought. Here, we test two fundamental assumptions of this hypothesis in Clarkia xantiana: (1) that a seasonal decline in precipitation causes an increase in drought stress and (2) that this results in changes in physiological performance, reflecting these deteriorating conditions. METHODS: We examined seasonal and interannual variation in abiotic environmental conditions (estimated by ambient temperature, relative humidity, predawn leaf water potentials, and carbon isotope ratios) and physiological traits (photosynthesis, conductance, transpiration, instantaneous water-use efficiency, ascorbate peroxidase and glutathione reductase activities, quantum yield of photosystem II, PSII potential efficiency) in field populations of C. xantiana in 2009 and 2010. KEY RESULTS: In both years, plants experienced intensifying drought across the growing season. Gas exchange rates decreased over the growing season and were lower in 2009 (a relatively dry year) than in 2010, suggesting that the temporal changes from early to late spring were directly linked to the deteriorating environmental conditions. CONCLUSIONS: Seasonal declines in transpiration rate may have increased survival by protecting plants from desiccation. Concomitant declines in photosynthetic rate likely reduced the availability of resources for seed production late in the season. Thus, the physiological patterns observed are consistent with the conditions required for the drought escape hypothesis.

Elia, V., et al. (2015). "Permanent dissipative structures in water: the matrix of life? Experimental evidences and their quantum origin." Curr Top Med Chem **15**(6): 559-571.

This paper presents a short review of the evidence - both experimental and theoretical - of the formation of dissipative structures in liquid water induced by three kinds of physical perturbations having a low energy content: extremely diluted solution (EDS), iteratively filtered water (IFW), and iteratively nafionated water (INW). Particular attention is devoted to the very recent discovery that such structures are tremendously persistent even in the solid phase: large ponderal quantities of supramolecular aggregates of water (with each nucleus hundreds of nanometers in size) have been observed - at ambient pressure and temperature - using easily-reproducible experimental methods. The nature of these dissipative structures is analyzed and explained in terms of the thermodynamics of far-from-equilibrium systems and irreversible processes, showing their spontaneous quantum origin. Are these kinds of structures the matrix itself of life?.

Fiser, B., et al. (2015). "Glutathione as a prebiotic answer to alpha-peptide based life." J Phys Chem B **119**(10): 3940-3947.

The energetics of peptide bond formation is an important factor not only in the design of chemical peptide synthesis, but it also has a role in protein biosynthesis. In this work, quantum chemical calculations at 10 different levels of theory including G3MP2B3 were performed on the energetics of glutathione formation. The strength of the peptide bond is found to be closely related to the acid strength of the to-be N-terminal and the basicity of the to-be C-terminal amino acid. It is shown that the formation of the first peptide activates the amino acid for the next condensation step, manifested in bacterial protein synthesis where the first step is the formation of an N-formylmethionine dipeptide. The possible role of glutathione in prebiotic molecular evolution is also analyzed. The implications of the thermodynamics of peptide bond formation in prebiotic peptide formation as well as in the preference of alpha- instead of beta- or gamma-amino acids are discussed. An empirical correction is proposed for the compensation of the error due to the incapability of continuum solvation models in describing the change of the first solvation shell when a peptide bond is formed from two zwitterions accompanied by the disappearance of one ion pair.

Germano, R. (2015). "Water's quantum structures and life." Electromagn Biol Med **34**(2): 133-137.

This article discusses several clues pointing to the spontaneous quantum origin of the recently discovered dissipative structures induced in liquid water by low-energy physical perturbations. These structures show an astonishing permanence, so much that large ponderal quantities of supramolecular aggregates of water - at ambient pressure and temperature - subsist even in the solid phase, strongly suggesting the possibility that these structures are the matrix itself of life.

Goodman, G. and M. E. Gershwin (2011). "Physics, biology and the origin of life: the physicians' view." Isr Med Assoc J **13**(12): 719-724.

Physicians have a great interest in discussions of life and its origin, including life's persistence through successive cycles of self-replication under extreme climatic and man-made trials and tribulations. We review here the fundamental processes that, contrary to human intuition, life may be seen heuristically as an ab initio, fundamental process at the interface between the complementary forces of gravitation and quantum mechanics. Analogies can predict applications of quantum mechanics to human physiology in addition to that already being applied, in particular to aspects of brain activity and pathology. This potential will also extend eventually to, for example, autoimmunity, genetic selection and aging. We present these thoughts in perspective against a background of changes in some physical fundamentals of science, from the earlier times of the natural philosophers of medicine to the technological medical gurus of today. Despite the enormous advances in medical science, including integration of technological changes that have led to the newer clinical applications of magnetic resonance imaging and PET scans and of computerized drug design, there is an intellectual vacuum as to how the physics of matter became translated to the biology of life. The essence and future of medicine continue to lie in cautious, systematic and ethically bound practice and scientific research based on fundamental physical laws accepted as true until proven false.

Goswami, A. (1997). "Consciousness and biological order: toward a quantum theory of life and its evolution." Integr Physiol Behav Sci **32**(1): 86-100.

Biological order is discussed within the context of the idealist interpretation of quantum mechanics. A quantum mechanism is proposed for quantum speciation and for quantum evolution, in general. It is shown that an extension of neo-Darwinism to include quantum evolution via a quantum mechanism can resolve some of the recent controversies that have rattled evolution theory. It is pointed out that the quantum approach has the further benefit of giving a straightforward insight into the nature of life itself. Experimental support for some aspects of the theory is discussed.

Gozani, O., et al. (2002). "Life and death in paradise." Nat Cell Biol **4**(6): E159-162.

Over 500 researchers participated in a recent American Association for Cancer Research special conference, entitled "Apoptosis and Cancer: Basic Mechanisms and Therapeutic Opportunities in the Post-Genomic Era" (February 13-17, 2002) in sunny Hawaii (Hilton Waikoloa village, Kona, Hawaii). The meeting participants presented the most recent findings on the mechanisms regulating cell death in cancer. In the past decade, apoptosis research has undergone a quantum leap, metamorphosing from a descriptive, phenomenological discipline into a molecularly defined, highly complex signalling field. This transformation was highlighted in the conference's opening talk by meeting co-organizer, John Reed (The Burnham Institute, La Jolla, CA). Reed and colleagues used published protein functional information and bio-informatic mining of the available human genome databases to tabulate the number of human proteins predicted to be involved in regulating apoptosis. The list includes 11 catalytically active caspases, 26 CARD (caspase associated recruitment domain)-, 32 DD (death domain)-, 12 DED (death effector domain)-, 8 BIR (baculovirus inhibitor of apoptosis protein region)-, 24 BH (Bcl-2 homology)-, and 34 PAAD/PYD (pyrin/PAAD)-containing sequences.

Hanaki, K., et al. (2003). "Semiconductor quantum dot/albumin complex is a long-life and highly photostable endosome marker." Biochem Biophys Res Commun **302**(3): 496-501.

For the purpose of selecting the efficient dispersion condition of hydrophilic semiconductor quantum dots (QDs) in biological buffers, the dispersion of the QDs mixed with a serum albumin from 9 different species or an ovalbumin was compared by a fluorescence intensity analysis. The QDs mixed with sheep serum albumin (SSA) showed the highest fluorescence of all when the mixtures were dissolved in Dulbecco's MEM. QD/SSA complexes were accumulated in the endosome/lysosome of Vero cells and the fluorescence could be detected over a 5-day post-incubation period. The photostability of QD/SSA complexes associated with the endosomes was detectable, at least, 30 times as long as that of fluorescein-labeled dextran involved in endosomes. QD/SSA complex, therefore, can be used as a long-life and highly photostable endosome marker.

Haydon, N., et al. (2011). "Speculation on quantum mechanics and the operation of life giving catalysts." Orig Life Evol Biosph **41**(1): 35-50.

The origin of life necessitated the formation of catalytic functionalities in order to realize a number of those capable of supporting reactions that led to the proliferation of biologically accessible molecules and the formation of a proto-metabolic network. Here, the discussion of the significance of quantum behavior on biological systems is extended from recent hypotheses exploring brain function and DNA mutation to include origins of life considerations in light of the concept of quantum decoherence and the transition from the quantum to the classical. Current understandings of quantum systems indicate that in the context of catalysis, substrate-catalyst interaction may be considered as a quantum measurement problem. Exploration of catalytic functionality necessary for life's emergence may have been accommodated by quantum searches within metal sulfide compartments, where catalyst and substrate wave function interaction may allow for quantum based searches of catalytic phase space. Considering the degree of entanglement experienced by catalytic and non catalytic outcomes of superimposed states, quantum contributions are postulated to have played an important role in the operation of efficient catalysts that would provide for the kinetic basis for the emergence of life.

He, Y. J., et al. (2000). "Effect of earth's orbital chirality on elementary particles and unification of chiral asymmetries in life on different levels." Med Hypotheses **54**(5): 783-785.

Life is chirally asymmetric at all scales from microscopic elementary particles to molecular and macroscopic levels. How these chiral asymmetries in life on different levels are unified remains unanswered. It has been demonstrated that both the biomolecular homochirality and biological rhythms can be caused by the right-handed helical force-field of the Earth's orbital chirality (EOC). Similar to the helical biomolecules (1), it is here suggested that the right-handed EOC force-field could make the right-handed elementary particles more stable than their left-handed enantiomers to result in the symmetry violation of elementary particles, and the EOC could also cause the macroscopic predominant selection of right-handed asymmetries of living objects (e.g. the helical seashells and plants). Our studies indicated that the weak force in weak interaction may only be a form of the EOC force-field at the microscopic particle level, and the chiral asymmetries in life on various levels could be unified by the natural right-handed EOC force-field. Moreover, the chiral and quantum effects, time, mass, rhythms and relativity could also be unified by the interaction of the EOC force-field with chiral motions and structures under certain conditions.

Ho, M. W. (2015). "Illuminating water and life: Emilio Del Giudice." Electromagn Biol Med **34**(2): 113-122.

The quantum electrodynamics theory of water put forward by Del Giudice and colleagues provides a useful foundation for a new science of water for life. The interaction of light with liquid water generates quantum coherent domains in which the water molecules oscillate between the ground state and an excited state close to the ionizing potential of water. This produces a plasma of almost free electrons favoring redox reactions, the basis of energy metabolism in living organisms. Coherent domains stabilized by surfaces, such as membranes and macromolecules, provide the excited interfacial water that enables photosynthesis to take place, on which most of life on Earth depends. Excited water is the source of superconducting protons for rapid intercommunication within the body. Coherent domains can also trap electromagnetic frequencies from the environment to orchestrate and activate specific biochemical reactions through resonance, a mechanism for the most precise regulation of gene function.

Hou, H., et al. (2015). "Carbon Quantum Dots and Their Derivative 3D Porous Carbon Frameworks for Sodium-Ion Batteries with Ultralong Cycle Life." Adv Mater **27**(47): 7861-7866.

A new methodology for the synthesis of carbon quantum dots (CQDs) for large production is proposed. The as-obtained CQDs can be transformed into 3D porous carbon frameworks exhibiting superb sodium storage properties with ultralong cycle life and ultrahigh rate capability, comparable to state-of-the-art carbon anode materials for sodium-ion batteries.

Hunt, T. (2013). "The rainbow and the worm: Establishing a new physics of life." Commun Integr Biol **6**(2): e23149.

What is life? Many have asked this question, and no definitive answer is yet widely accepted. Is life something truly distinct from non-living stuff, as many dualists have suggested for millennia? Is there an elan vital that distinguishes living from dead stuff? Or is life about certain types of organization, metabolism, reproduction, goal-oriented behavior? None of these answers have yet won the debate. There is, however, an intriguing new set of ideas that have been developed by Mae-Wan Ho, a biophysicist and science activist (as she calls herself) based in London. Ho's basic assertion is that life exists on a spectrum and is at its root organized, quantum coherent energy. Ho's

work attempts to bridge the gap between physics and biology by recognizing that there is no real gap at all-just a gap in current methods and habits of thinking.

Igamberdiev, A. U. (2007). "Physical limits of computation and emergence of life." Biosystems **90**(2): 340-349.

The computational process is based on the activity linking mathematical equations to a materialized physical world. It consumes energy which lower limit is defined by the set of Planck's values, i.e. by the physical structure of the Universe. We discuss computability from the quantum measurement framework. Effective quantum computation is possible via the maintenance of a long-living cold decoherence-free internal state, which is achieved by applying error-correction commands to it and by screening it from thermal fluctuations. The quantum Zeno effect enables coherent superpositions and entanglement to persist for macroscopic time intervals. Living systems maintain coherent states via realization of their own computing programs aiming them to survive and develop, while their non-computable behavior corresponds to a generative power that arises beyond combinatorial capabilities of the system. Emergence of life brings in the Universe a creative activity that overcomes the limits of computability.

Izmaylov, D. M., et al. (1993). "Phenomenon of life span instability in Drosophila melanogaster: II. Change in rhythm of natural variations of life span after single exposure to gamma-irradiation." Exp Gerontol **28**(2): 181-194.

The dynamics of life span (LS) have been studied in successive generations of postirradiation and control groups of Drosophila melanogaster, strain D-32, after a single exposure to Co60 gamma-quantum irradiation. It has been shown using mathematical procedures that in all postirradiation generations, with one exception, survival curves retain their canonical shape. This is indicative of the unchangeable nature of LS distribution. The mean LS of the progeny of irradiated parents either coincides with control values or can be higher or lower. Moreover, single irradiation results in an altered time-scanning of LS variations in successive generations as compared with controls. The possible origin of LS instability is discussed.

Izumi, Y. and K. Nakagawa (2011). "Quantum yields of decomposition and homo-dimerization of solid L-alanine induced by 7.2 eV Vacuum ultraviolet light irradiation: an estimate of the half-life of L-alanine on the surface of space objects." Orig Life Evol Biosph **41**(4): 385-395.

One of the leading hypotheses regarding the origin of prebiotic molecules on primitive Earth is that they formed from inorganic molecules in extraterrestrial environments and were delivered by meteorites, space dust and comets. To evaluate the availability of extraterrestrial amino acids, it is necessary to examine their decomposition and oligomerization rates as induced by extraterrestrial energy sources, such as vacuum ultraviolet (VUV) and X-ray photons and high energy particles. This paper reports the quantum yields of decomposition ((8.2 +/- 0.7) x 10(-2) photon (-1)) and homo-dimerization ((1.2 +/- 0.3) x 10(-3) photon (-1)) and decomposition of the dimer (0.24 +/- 0.06 photon (-1)) of solid L-alanine (Ala) induced by VUV light with an energy of 7.2 eV. Using these quantum yields, the half-life of L-Ala on the surface of a space object in the present earth orbit was estimated to be about 52 days, even when only photons with an energy of 7.2 eV emitted from the present Sun were considered. The actual half-life of solid L-Ala on the surface of a space object orbit around the present day Earth would certainly be much shorter than our estimate, because of the added effect of photons and particles of other energies. Thus, we propose that L-Ala needs to be shielded from solar VUV in protected environments, such as the interior of a meteorite, within a time scale of days after synthesis to ensure its arrival on the primitive Earth.

Jacobson, J. I. (1989). "On the electro-magnetic nature of life." Panminerva Med **31**(4): 151-165.

Man has wondered since the dawning of thought about the origin and the meaning of the spark of life. How does life work and what is the difference between life and non-life? This paper wonders about the part that electromagnetism plays in the life process. It proposes a new insight into the relation of in vivo electromagnetic fields and gravitational fields and discusses such manifestations as solitons, the quantum hall effect, gravity waves, biological strings, biologically closed electric circuits, phonos and the piezoelectric nature of living tissue. It proposes a new and fundamental form of resonance, called Jacobson resonance. The system unifies quantum genetic characters and associated structures with electromagnetic field interaction energies. The result is the reorientation of atomic crystal lattice structures of organic molecules critical to the sustenance of life. A new treatment methodology is proposed for genomic, viral and trophic factor disorders essentially in terms of the potential efficacy of the magnetic force to reorient the spin angular momenta of electrons and protons; to therein rearrange atomic and molecular magnetic domains regulating homeostasis on microscopic, mesosopic and macroscopic levels through biological amplification of quantum interactions. Finally it proposes that the equation, mc2 = Bvl coulomb, may indeed represent the achievement

of fourfold physical unification, the unification of physics and medicine, and resultant production of a thorough understanding of what may be the most fundamental natural law of the universe representing the ultimate goal of Einsteinian equivalence and relativistic field theory.

Jaeken, L. (2006). "Linking physiological mechanisms of coherent cellular behaviour with more general physical approaches towards the coherence of life." IUBMB Life **58**(11): 642-646.

Schrodinger pointed out that one of the most fundamental properties of life is its coherent behaviour. This property has been approached from a physiological point of view by Ling in his 'association-induction hypothesis' and extended by Pollack (gel-sol theory), by Chaplin and by Kaivarainen (detailed studies of cellular water). The question of coherence has also been attacked from general physics in three independent approaches: from non-linear thermodynamics (Frohlich), from quantum field theory (Del Giudice and his group) and from quantum mechanics (Davydov). In this paper all these approaches are unified. The emerging picture constitutes a new paradigm of life.

Karpinski, S. and M. Szechynska-Hebda (2010). "Secret life of plants: from memory to intelligence." Plant Signal Behav **5**(11): 1391-1394.

Plants are able to perform photosynthesis and cannot escape from environmental stresses, so they therefore developed sophisticated, highly responsive and dynamic physiology. Others' and our results indicate that plants solve their optimal light acclimation and immune defenses, photosynthesis and transpiration by a computational algorithm of the cellular automation. Our recent results however suggest that plants are capable of processing information encrypted in light intensity and in its energy. With the help of nonphotochemical quenching and photoelectrophysiological signaling (PEPS) plants are able to perform biological quantum computation and memorize light training in order to optimize their Darwinian fitness. Animals have their network of neuron synapses, electrophysiological circuits and memory, but plants have their network of chloroplasts connected by stromules, PEPS circuits transduced by bundle sheath cells and cellular light memory. It is suggested that plants could be intelligent organisms with much higher organism organization levels than it was thought before.

Kauffman, S. A. and A. Gare (2015). "Beyond Descartes and Newton: Recovering life and humanity." Prog Biophys Mol Biol **119**(3): 219-244.

Attempts to 'naturalize' phenomenology challenge both traditional phenomenology and traditional approaches to cognitive science. They challenge Edmund Husserl's rejection of naturalism and his attempt to establish phenomenology as a foundational transcendental discipline, and they challenge efforts to explain cognition through mainstream science. While appearing to be a retreat from the bold claims made for phenomenology, it is really its triumph. Naturalized phenomenology is spearheading a successful challenge to the heritage of Cartesian dualism. This converges with the reaction against Cartesian thought within science itself. Descartes divided the universe between res cogitans, thinking substances, and res extensa, the mechanical world. The latter won with Newton and we have, in most of objective science since, literally lost our mind, hence our humanity. Despite Darwin, biologists remain children of Newton, and dream of a grand theory that is epistemologically complete and would allow lawful entailment of the evolution of the biosphere. This dream is no longer tenable. We now have to recognize that science and scientists are within and part of the world we are striving to comprehend, as proponents of endophysics have argued, and that physics, biology and mathematics have to be reconceived accordingly. Interpreting quantum mechanics from this perspective is shown to both illuminate conscious experience and reveal new paths for its further development. In biology we must now justify the use of the word "function". As we shall see, we cannot prestate the ever new biological functions that arise and constitute the very phase space of evolution. Hence, we cannot mathematize the detailed becoming of the biosphere, nor write differential equations for functional variables we do not know ahead of time, nor integrate those equations, so no laws "entail" evolution. The dream of a grand theory fails. In place of entailing laws, a post-entailing law explanatory framework is proposed in which Actuals arise in evolution that constitute new boundary conditions that are enabling constraints that create new, typically unprestatable, Adjacent Possible opportunities for further evolution, in which new Actuals arise, in a persistent becoming. Evolution flows into a typically unprestatable succession of Adjacent Possibles. Given the concept of function, the concept of functional closure of an organism making a living in its world, becomes central. Implications for patterns in evolution include historical reconstruction, and statistical laws such as the distribution of extinction events, or species per genus, and the use of formal cause, not efficient cause, laws.

Kobeissy, F. H., et al. (2014). "Post-genomics nanotechnology is gaining momentum:

nanoproteomics and applications in life sciences." OMICS **18**(2): 111-131.

The post-genomics era has brought about new Omics biotechnologies, such as proteomics and metabolomics, as well as their novel applications to personal genomics and the quantified self. These advances are now also catalyzing other and newer post-genomics innovations, leading to convergences between Omics and nanotechnology. In this work, we systematically contextualize and exemplify an emerging strand of post-genomics life sciences, namely, nanoproteomics and its applications in health and integrative biological systems. Nanotechnology has been utilized as a complementary component to revolutionize proteomics through different kinds of nanotechnology applications, including nanoporous structures, functionalized nanoparticles, quantum dots, and polymeric nanostructures. Those applications, though still in their infancy, have led to several highly sensitive diagnostics and new methods of drug delivery and targeted therapy for clinical use. The present article differs from previous analyses of nanoproteomics in that it offers an in-depth and comparative evaluation of the attendant biotechnology portfolio and their applications as seen through the lens of post-genomics life sciences and biomedicine. These include: (1) immunosensors for inflammatory, pathogenic, and autoimmune markers for infectious and autoimmune diseases, (2) amplified immunoassays for detection of cancer biomarkers, and (3) methods for targeted therapy and automatically adjusted drug delivery such as in experimental stroke and brain injury studies. As nanoproteomics becomes available both to the clinician at the bedside and the citizens who are increasingly interested in access to novel post-genomics diagnostics through initiatives such as the quantified self, we anticipate further breakthroughs in personalized and targeted medicine.

Korotkov, K., et al. (2004). "Assessing biophysical energy transfer mechanisms in living systems: the basis of life processes." J Altern Complement Med **10**(1): 49-57.

OBJECTIVE: To explain the energetic physiologic basis for acupuncture electroconductance effects and for gas discharge visualization (GDV) assessment methods, using a quantum biophysical model of entropy and information flows. DESCRIPTION: The main reservoir of free energy in biologic processes is electron-excited states of complex molecular systems. Communities of delocalized excited pi-electrons in protein macromolecules are the basis of this energy reservoir. Specific structural-protein complexes within the mass of the skin provide channels of heightened electron conductivity, measured at acupuncture points on the surface. Stimulated impulse emissions from the skin are also developed mainly by transport of delocalized pi-electrons. Stimulated by high voltage impulses, optical emissions, with amplification in gaseous discharge, are registered by optical sensors (GDV). This quantum model supports an argument that GDV techniques provide indirect judgment about the level of energy resources at the molecular level of functioning in structural-protein complexes. Several years of GDV research have provided clinical correlations with well-accepted physiologic parameters. For example, postsurgery recovery progress is correlated with GDV parameters and GDV assessments provide independent diagnostic measures of psychophysical reserves in athletes. CONCLUSION: GDV methods for investigating human functional states, by assessing electro-optical parameters of the skin, are based on the registration of physical processes emerging from electron components of tissue conductivity.

Kulik, L. V., et al. (2015). "Super-long life time for 2D cyclotron spin-flip excitons." Sci Rep **5**: 10354.

An experimental technique for the indirect manipulation and detection of electron spins entangled in two-dimensional magnetoexcitons has been developed. The kinetics of the spin relaxation has been investigated. Photoexcited spin-magnetoexcitons were found to exhibit extremely slow relaxation in specific quantum Hall systems, fabricated in high mobility GaAs/AlGaAs structures; namely, the relaxation time reaches values over one hundred microseconds. A qualitative explanation of this spin-relaxation kinetics is presented. Its temperature and magnetic field dependencies are discussed within the available theoretical framework.

Leake, M. C. (2013). "The physics of life: one molecule at a time." Philos Trans R Soc Lond B Biol Sci **368**(1611): 20120248.

The esteemed physicist Erwin Schrodinger, whose name is associated with the most notorious equation of quantum mechanics, also wrote a brief essay entitled 'What is Life?', asking: 'How can the events in space and time which take place within the spatial boundary of a living organism be accounted for by physics and chemistry?' The 60+ years following this seminal work have seen enormous developments in our understanding of biology on the molecular scale, with physics playing a key role in solving many central problems through the development and application of new physical science techniques, biophysical analysis and rigorous intellectual insight. The early days of single-molecule biophysics research was centred around molecular motors and biopolymers, largely divorced from a real

physiological context. The new generation of single-molecule bioscience investigations has much greater scope, involving robust methods for understanding molecular-level details of the most fundamental biological processes in far more realistic, and technically challenging, physiological contexts, emerging into a new field of 'single-molecule cellular biophysics'. Here, I outline how this new field has evolved, discuss the key active areas of current research and speculate on where this may all lead in the near future.

Leapman, R. D. (2017). "Application of EELS and EFTEM to the life sciences enabled by the contributions of Ondrej Krivanek." Ultramicroscopy **180**: 180-187.

The pioneering contributions of Ondrej Krivanek to the development of electron energy loss spectrometers, energy filters, and detectors for transmission and scanning transmission electron microscopes have provided researchers with indispensible tools across a wide range of disciplines in the physical sciences, ranging from condensed matter physics, to chemistry, mineralogy, materials science, and nanotechnology. In addition, the same instrumentation has extended its reach into the life sciences, and it is this aspect of Ondrej Krivanek's influential contributions that will be surveyed here, together with some personal recollections. Traditionally, electron microscopy has given a purely morphological view of the biological structures that compose cells and tissues. However, the availability of high-performance electron energy loss spectrometers and energy filters offers complementary information about the elemental and chemical composition at the subcellular scale. Such information has proven to be valuable for applications in cell and structural biology, microbiology, histology, pathology, and more generally in the biomedical sciences.

Lee, S. F. and M. A. Osborne (2009). "Brightening, blinking, bluing and bleaching in the life of a quantum dot: friend or foe?" Chemphyschem **10**(13): 2174-2191.

Semiconductor nanocrystals or quantum dots (QDs) are highly photoluminescent materials with unique optical attributes that are being exploited in an ever-increasing array of applications. However, the complex surface chemistry of these finite-sized fluorophores gives rise to a number of photophysical phenomena that can complicate their use in imaging applications. Fluorescence intermittency (FI), photoluminescence enhancement (PLE) and spectral bluing are properties of QD emission that would appear, at first sight, detrimental to quantitative measurement. Fortunately, developments in rational QD synthesis and surface modification are promising to minimize the effects of these fluorescence instabilities, while applications that exploit them are now coming to the fore. We review recent experimental and theoretical studies of FI, PLE and bluing, highlighting the benefits, as well as complications, they bring to key applications.

Lee, T. C., et al. (2009). "Syntheses, photophysics, and application of iridium (III) phosphorescent emitters for highly efficient, long-life organic light-emitting diodes." Chem Asian J **4**(5): 742-753.

Rational design and synthesis of Ir (III) complexes (1-3) bearing two cyclometalated ligands (C--N) and one 2-(diphenylphosphino) phenolate chelate (P--O) as well as the corresponding Ir (III) derivatives (4-6) with only one (C--N) ligand and two P--O chelates are reported, where (C--NH)=phenylpyridine (ppyH), 1-phenylisoquinoline (piqH), and 4-phenylquinazoline (nazoH). Single crystal X-ray diffraction studies of 3 reveal a distorted octahedral coordination geometry, in which two nazo ligands adopt an eclipsed configuration, with the third P--O ligand located trans to the phenyl group of both nazo ligands, confirming the general skeletal pattern for 1-3. In sharp contrast, complex 4 reveals a trans-disposition for the PPh2 groups, along with the phenolate groups residing opposite the unique cyclometalated ppy ligand, which is the representative structure for 4-6. These Ir (III) complexes exhibit green-to-red photoluminescence with moderate to high quantum efficiencies in the degassed fluid state and bright emission in the solid state. For 1-6, the resolved emission spectroscopy and relaxation dynamics are well rationalized by the computational approach. OLEDs fabricated using 12 wt. % of 3 doped in CBP and with BCP as hole blocking material, give bright electroluminescence with lambda (max)=628 nm and CIE (xy) coordinates (0.65, 0.34). The turn-on voltage is 3.2 V, while the current efficiency and the power efficiency reach 11.2 cd A (-1) and 4.5 lm W (-1) at 20 mA cm (-2). The maximum efficiency reaches 14.7 cd A (-1) and 6.8 lm W (-1) upon switching to TPBI as hole blocking material. For evaluating device lifespan, the tested device incorporating CuPc as a passivation layer, 3 doped in CTP as an emitting layer, and BAlq as hole blocking material, shows a remarkably long lifetime up to 36,000 h at an initial luminance of 500 cd m (-2).

Li, Y., et al. (2016). "Orbital Selective Spin Excitations and their Impact on Superconductivity of LiFe_{1-x}Co_{x}As." Phys Rev Lett **116**(24): 247001.

We use neutron scattering to study spin excitations in single crystals of LiFe_{0.88}Co_{0.12}As, which is located near the boundary of the superconducting phase of LiFe_{1-x}Co_{x}As and exhibits non-Fermi-liquid behavior indicative of a quantum critical point. By comparing spin excitations of LiFe_{0.88}Co_{0.12}As with a combined density functional theory and dynamical mean field theory calculation, we conclude that wave-vector correlated low energy spin excitations are mostly from the d_{xy} orbitals, while high-energy spin excitations arise from the d_{yz} and d_{xz} orbitals. Unlike most iron pnictides, the strong orbital selective spin excitations in the Li Fe As family cannot be described by an anisotropic Heisenberg Hamiltonian. While the evolution of low-energy spin excitations of LiFe_{1-x}Co_{x}As is consistent with the electron-hole Fermi surface nesting conditions for the d_{xy} orbital, the reduced superconductivity in LiFe_{0.88}Co_{0.12}As suggests that Fermi surface nesting conditions for the d_{yz} and d_{xz} orbitals are also important for superconductivity in iron pnictides.

Luger, P. (2007). "Fast electron density methods in the life sciences--a routine application in the future?" Org Biomol Chem **5**(16): 2529-2540.

The understanding of mutual recognition of biologically interacting systems on an atomic scale is of paramount importance in the life sciences. Electron density distributions that can be obtained from a high resolution X-ray diffraction experiment can provide--in addition to steric information--electronic properties of the species involved in these interactions. In recent years experimental ED methods have seen several favourable developments towards successful application in the life sciences. Experimental and methodological advances have made possible on the one hand high-speed X-ray diffraction experiments, and have allowed on the other hand the quantitative derivation of bonding, non-bonding and atomic electronic properties. This has made the investigation of a large number of molecules possible, and moreover, molecules with 200 or more atoms can be subject of experimental ED studies, as has been demonstrated by the example of vitamin B12. Supported by the experimentally verified transferability concept of submolecular electronic properties, a key issue in Bader's The Quantum Theory of Atoms in Molecules, activities have emerged to establish databases for the additive generation of electron densities of macromolecules from submolecular building blocks. It follows that the major aims of any experimental electron density work in the life sciences, namely the generation of electronic information for a series of molecules in a reasonable time and the study of biological macromolecules (proteins, polynucleotides), are within reach in the near future.

Mader, O., et al. (2004). "Structure property analysis of pentamethine indocyanine dyes: identification of a new dye for life science applications." Bioconjug Chem **15**(1): 70-78.

A collection of nine pentamethine indocyanine dyes was synthesized, and the photophysical characteristics relevant to applications in cell biology and single molecule detection were analyzed in detail. Substituents at the aromatic system covering the auxochromic series and substitutions in the polymethine chain were investigated with respect to absorption and emission spectra, fluorescence lifetimes, fluorescence quantum yields, and fluorescence autocorrelations. Substitutions in the polymethine chain increased the nonradiative energy dissipation of the excited singlet state and decreased the fluorescence quantum yield, relative to the unsubstituted compound. For substituents at the aromatic rings the fluorescence quantum yield negatively correlates with the position of the substituents in the auxochromic series -SO (3) (-), -H, -F, -CH (3). Compounds with sulfonic acid groups or halogen atoms attached to the indolenine systems had the highest fluorescence quantum yields. The compound S0387 had nearly 70% of the quantum yield of Cy5 and comparable photostability. The free carboxylic acid of S0387 was attached to peptides in high yield and purity by established procedures of solid-phase synthesis. The dye-labeled peptides did not aggregate or bind to tissue culture cells and proteins unspecifically. The indocyanine dye S0387 is therefore an attractive new fluorophore for in vitro and cell-based detection of receptor ligand interaction at nanomolar concentrations by flow cytometry, fluorescence correlation spectroscopy, and laser scanning microscopy.

Marinkovic, S., et al. (2015). "Nature, life and mind. An essay on the essence." Folia Morphol (Warsz) **74**(3): 273-282.

BACKGROUND: Our long-standing scientific work and love to the fine art and nature for many years succeeded in making a unifying description of the three domains, at a time when a high specialisation in science, and even in art, has neglected the necessary entirety. MATERIALS AND METHODS: Some neurons of a rat cerebral cortex were labelled with true blue and photographed under a fluorescent microscope. A monkey brain was sectioned in the axial plane. Several slices of the human motor cortex were stained with cresyl violet. A cerebral hemisphere image was modified, and another image was created in

Adobe Photoshop. RESULTS: Some 10 billion years after the Big Bang life appeared on the Earth, reaching its peak with development of the brain. The humans started exploration of the local nature to survive, and the universe for psychological support. The antique philosophers Leucippes, Democritus and Heraclitus were the first to create a unifying atomic theory and to suggest the eternal movement of the matter. Newton and Kepler explained the movement of the celestial objects, whereas Einstein, Planck, Bohr, Hubbel, Howking and many others connected the quantum physics and elementary forces with the essence of the universe. Leonardo da Vinci, and later many others as well, united science and art. Philosophers and mathematicians created the phenomena which do not exist in nature. CONCLUSIONS: Nature designed the human brain, more complex than the universe itself, which in turn created millions of the artworks and scientific discoveries. The might of the mind in some domains overcomes the power of nature.

Marletto, C. (2015). "Constructor theory of life." J R Soc Interface **12**(104): 20141226.

Neo-Darwinian evolutionary theory explains how the appearance of purposive design in the adaptations of living organisms can have come about without their intentionally being designed. The explanation relies crucially on the possibility of certain physical processes: mainly, gene replication and natural selection. In this paper, I show that for those processes to be possible without the design of biological adaptations being encoded in the laws of physics, those laws must have certain other properties. The theory of what these properties are is not part of evolution theory proper, yet without it the neo-Darwinian theory does not fully achieve its purpose of explaining the appearance of design. To this end, I apply constructor theory's new mode of explanation to express exactly within physics the appearance of design, no-design laws, and the logic of self-reproduction and natural selection. I conclude that self-reproduction, replication and natural selection are possible under no-design laws, the only non-trivial condition being that they allow digital information to be physically instantiated. This has an exact characterization in the constructor theory of information. I also show that under no-design laws an accurate replicator requires the existence of a 'vehicle' constituting, together with the replicator, a self-reproducer.

Matsuno, K. (1997). "Molecular semantics and the origin of life." Biosystems **42**(2-3): 129-139.

The physical origin of life addresses itself to a semantic process on material grounds, in which causation toward contextualization is at work. Physically semantic process of whatever kind is specific in that every material participant is searching and modifying the material context to be fitted in. Fundamental to the physical semantics is the process of measurement proceeding internally among the constituent material participants, whereas the molecular syntax alone as embodied in the form of the quantum-mechanical equation of motion supplemented independently by exogenous boundary conditions cannot cope with the material process underlying the origin. A basic physical attribute of the phenomenon called life is variable duration, in contrast to invariant duration of Galilean inertia. In fact, moleculars replication thought as a harbinger of the phenomenon of life is a concrete form of variable duration and could be established unless internal measurement being instrumental to physically semantic process is forcibly eliminated by some external means. Physical experiments on the onset of molecular replication could become feasible only when external controllability over the intended experiments even at nano-meter scales is abandoned so as to save the room of internal measurement on the part of participating molecules.

Mayer, S. (1989). "Wholly life: a new perspective on death." Holist Nurs Pract **3**(4): 72-80.

When caring for the dying, the holistic nurse must be cognizant of many factors involved in this extraordinary process. Many of these factors, including the phenomena of the fear of death, the influences that cause it, and the behavior associated with it, have been discussed in this article. This article presented a new perspective of death in the light of recent discoveries in quantum physics. The concepts of one-ness, self-awareness, and love, together with their relevance to the nurse, have been explored. Grounded in this new paradigm, the holistic nurse serves as a bridge between an old way of seeing and a new way of being.

McInerney, J. O., et al. (2011). "The Public Goods Hypothesis for the evolution of life on Earth." Biol Direct **6**: 41.

It is becoming increasingly difficult to reconcile the observed extent of horizontal gene transfers with the central metaphor of a great tree uniting all evolving entities on the planet. In this manuscript we describe the Public Goods Hypothesis and show that it is appropriate in order to describe biological evolution on the planet. According to this hypothesis, nucleotide sequences (genes, promoters, exons, etc.) are simply seen as goods, passed from organism to organism through both vertical and horizontal transfer. Public goods sequences are defined by having the properties of being largely non-excludable (no organism can be

effectively prevented from accessing these sequences) and non-rival (while such a sequence is being used by one organism it is also available for use by another organism). The universal nature of genetic systems ensures that such non-excludable sequences exist and non-excludability explains why we see a myriad of genes in different combinations in sequenced genomes. There are three features of the public goods hypothesis. Firstly, segments of DNA are seen as public goods, available for all organisms to integrate into their genomes. Secondly, we expect the evolution of mechanisms for DNA sharing and of defense mechanisms against DNA intrusion in genomes. Thirdly, we expect that we do not see a global tree-like pattern. Instead, we expect local tree-like patterns to emerge from the combination of a commonage of genes and vertical inheritance of genomes by cell division. Indeed, while genes are theoretically public goods, in reality, some genes are excludable, particularly, though not only, when they have variant genetic codes or behave as coalition or club goods, available for all organisms of a coalition to integrate into their genomes, and non-rival within the club. We view the Tree of Life hypothesis as a regionalized instance of the Public Goods hypothesis, just like classical mechanics and euclidean geometry are seen as regionalized instances of quantum mechanics and Riemannian geometry respectively. We argue for this change using an axiomatic approach that shows that the Public Goods hypothesis is a better accommodation of the observed data than the Tree of Life hypothesis.

McKaughan, D. J. (2005). "The influence of Niels Bohr on Max Delbruck: revisiting the hopes inspired by "light and life"." Isis **96**(4): 507-529.

The impact of Niels Bohr's 1932 "Light and Life" lecture on Max Delbruck's lifelong search for a form of "complementarity" in biology is well documented and much discussed, but the precise nature of that influence remains subject to misunderstanding. The standard reading, which sees Delbruck's transition from physics into biology as inspired by the hope that investigation of biological phenomena might lead to a breakthrough discovery of new laws of physics, is colored much more by Erwin Schrodinger's What Is Life? (1944) than is often acknowledged. Bohr's view was that teleological and mechanistic descriptions are mutually exclusive yet jointly necessary for an exhaustive understanding of life. Although Delbruck's approach was empirical and less self-consciously philosophical, he shared Bohr's hope that scientific investigation would vindicate the view that at least some aspects of life are not reducible to physico-chemical terms.

Meggs, W. J. (1998). "Biological homing: hypothesis for a quantum effect that leads to the existence of life." Med Hypotheses **51**(6): 503-506.

In biological systems, complex molecules interact with specificity and rapidity. The hypothesis is advanced that there are complementary sites on the surfaces of pairs of biological molecules with an enhanced attraction due to quantum mechanics. I postulate that a biological homing effect arises from the quantum mechanical probability that complementary pairs of molecules will join, and that this phenomenon is the force that drives biology and gives rise to the existence of life. To illustrate the approach, a simplified calculation is given for the interaction cross-section between two molecules, each with N surface charges that have an identical spatial distribution but with paired charges having opposite signs. The resulting cross-section is enhanced by a factor of N2 over the coulomb-scattering cross-section for a single pair of charges. We hypothesize that the existence of life is a direct and inevitable consequence of the principles presented here.

Miao, H., et al. (2015). "Observation of strong electron pairing on bands without Fermi surfaces in LiFe (1-x)CoxAs." Nat Commun **6**: 6056.

In conventional BCS superconductors, the quantum condensation of superconducting electron pairs is understood as a Fermi surface instability, in which the low-energy electrons are paired by attractive interactions. Whether this explanation is still valid in high-Tc superconductors such as cuprates and iron-based superconductors remains an open question. In particular, a fundamentally different picture of the electron pairs, which are believed to be formed locally by repulsive interactions, may prevail. Here we report a high-resolution angle-resolved photoemission spectroscopy study on LiFe (1-x)CoxAs. We reveal a large and robust superconducting gap on a band sinking below the Fermi level on Co substitution. The observed Fermi-surface-free superconducting order is also the largest over the momentum space, which rules out a proximity effect origin and indicates that the order parameter is not tied to the Fermi surface as a result of a surface instability.

Michaeli, K., et al. (2016). "The electron's spin and molecular chirality - how are they related and how do they affect life processes?" Chem Soc Rev **45**(23): 6478-6487.

The recently discovered chiral induced spin selectivity (CISS) effect gives rise to a spin selective electron transmission through biomolecules. Here we review the mechanism behind the CISS effect and its implication for processes in Biology. Specifically, three processes are discussed: long-range electron

transfer, spin effects on the oxidation of water, and enantioselectivity in bio-recognition events. These phenomena imply that chirality and spin may play several important roles in biology, which have not been considered so far.

Michaelian, K. (2017). "Microscopic dissipative structuring and proliferation at the origin of life." Heliyon **3**(10): e00424.

Some fundamental molecules of life are suggested to have been formed, proliferated, and evolved through photochemical microscopic dissipative structuring and autocatalytic proliferation under the UV-C/UV-B solar environment prevalent at Earth's surface throughout the Archean. Evidence is given in the numerous salient characteristics of these, including their strong absorption in this spectral region and their rapid non-radiative excited state decay through inherent conical intersections. The examples of the dissipative structuring and dissipative proliferation of the purines and of single strand DNA are given. UV-C and UV-B-induced stationary state isomerizations and tautomerizations are shown to be crucial to the formation of the purines from hydrogen cyanide in an aqueous environment under UV-C light, while UV-C induced phosphorylation of nucleosides and denaturing of double helix RNA and DNA are similarly important to the production and proliferation of single strand DNA. This thermodynamic dissipation perspective provides a physical-chemical foundation for understanding the origin and evolution of life.

Morandi, A., et al. (2011). "Advent of a Link between Ayurveda and Modern Health Science: The Proceedings of the First International Congress on Ayurveda, "Ayurveda: The Meaning of Life-Awareness, Environment, and Health" March 21-22, 2009, Milan, Italy." Evid Based Complement Alternat Med **2011**: 929083.

The First International Congress on Ayurveda was held in Milan, Italy in March 2009 and it has been the first scientific event of this kind in western world. This groundbreaking international congress was devoted to human being as the product of interactions between Awareness, Environment and Health, subjects that the West tends to consider separate and independent, but that are believed deeply connected in Ayurveda, whose interdependence defines "The Meaning of Life". The Congress established a bridge between indian and western philosophy, scientific and biomedical thinking in order to expand knowledge and healthcare. Main attention and address of the invited speakers was on the concept of "relationships" that, connecting living beings with environment, shape Nature itself. This concept is central in Ayurveda but is also common to other western scientific disciplines such as quantum physics and epigenetics that, in the four Sessions of the Congress, were represented by eminent experts. The importance of this event was underlined by the attendance of more than 400 participants and by noteworthy institutional endorsements, that added a significative political dimension of high social impact due to the topical period for CAM acceptance and integration in Europe.

Nadeau, J. L., et al. (2008). "Fluorescence microscopy as a tool for in situ life detection." Astrobiology **8**(4): 859-874.

The identification of extant and, in some cases, extinct bacterial life is most convincingly and efficiently performed with modern high-resolution microscopy. Epifluorescence microscopy of microbial autofluorescence or in conjunction with fluorescent dyes is among the most useful of these techniques. We explored fluorescent labeling and imaging of bacteria in rock and soil in the context of in situ life detection for planetary exploration. The goals were two-fold: to target non-Earth-centric biosignatures with the greatest possible sensitivity and to develop labeling procedures amenable to robotic implementation with technologies that are currently space qualified. A wide panel of commercially available dyes that target specific biosignature molecules was screened, and those with desirable properties (i.e., minimal binding to minerals, strong autofluorescence contrast, no need for wash steps) were identified. We also explored the potential of semiconductor quantum dots (QDs) as bacterial and space probes. A specific instrument for space implementation is suggested and discussed.

Negri, A., et al. (2005). "Effects of the herbicide diuron on the early life history stages of coral." Mar Pollut Bull **51**(1-4): 370-383.

The effects of the herbicide diuron on the early life history stages of broadcast spawning and brooding corals were examined in laboratory experiments. Fertilisation of Acropora millepora and Montipora aequituberculata oocytes were not inhibited at diuron concentrations of up to 1000 microg l (-1). Metamorphosis of symbiont-free A. millepora larvae was only significantly inhibited at 300 microg l (-1) diuron. Pocillopora damicornis larvae, which contain symbiotic dinoflagellates, were able to undergo metamorphosis after 24 h exposure to diuron at 1000 microg l (-1). Two-week old P. damicornis recruits on the other hand were as susceptible to diuron as adult colonies, with expulsion of symbiotic dinoflagellates (bleaching) evident at 10 microg l (-1) diuron after 96 h exposure. Reversible metamorphosis was observed at high diuron concentrations, with fully bleached polyps escaping from their skeletons. Pulse amplitude modulation (PAM) chlorophyll fluorescence

techniques demonstrated a reduction in photosynthetic efficiency (Delta F/F (m)') in illuminated P. damicornis recruits after a 2 h exposure to 1 microg l (-1) diuron. The dark-adapted quantum yields (F (v)/F (m)) also declined, indicating chronic photoinhibition and damage to photosystem II.

Nigam, M. C. (1990). "A new quantum mechanical theory of evolution of universe and life." Anc Sci Life **10**(2): 74-78.

Based upon the principles of ancient science of Life, which admits both consciousness and matter, a new Quantum Mechanical theory of evolution of universe and life is propounded. The theory advocates: Right from the time, the evolution of universe takes place, life also starts evolving energies and ethereal - consciousness (subtler and real) in anti-electrons, as the complimentary partners. The material body acquires electrons for cordoning of atomic nuclei and displaying its manifestation, in the three spatial dimensions in scale of time. The ethereal consciousness acquires anti electrons for gaining necessary energy for superimposing itself over any of the manifested bodies of equivalent electronic energy and deriving the bliss of materialization. The theory is based upon the solid foundation of the ancient science (ethereal consciousness) laid down by the ancient seekers of knowledge like Kapila and Caraka who interpret many of the riddles of modern science on the frontiers of various disciplines of knowledge.

Niu, J. F., et al. (2006). "QSPRs for the prediction of photodegradation half-life of PCBs in n-hexane." SAR QSAR Environ Res **17**(2): 173-182.

By partial least squares (PLS) regression analysis, a quantitative structure-property relationship (QSPR) model was developed for photodegradation half-life (t1/2) of polychlorinated biphenyls (PCBs) in n-hexane solution under UV irradiation. Quantum chemical descriptors computed by PM3 Hamiltonian were used as predictor variables. The cross-validated value for the optimal QSPR model was 0.589, indicating good predictive capability for log t1/2 values of PCBs in n-hexane. The QSPR results show that standard heat of formation (DeltaHf), total energy (TE), and molecular weight (Mw) have dominant effect on t1/2 values of PCBs in n-hexane. Increasing DeltaHf and TE values or decreasing Mw values of the PCBs leads to decrease of log t1/2 values. In addition, increasing the largest negative atomic charge on a carbon atom and dipole moment of the PCBs leads to decrease of log t1/2 values.

Osad'ko, I. S. (2014). "Two types of the relation between the intensity and the life time of photoluminescence of core/shell semiconductor quantum dots: important role of Coulomb field and tunneling transitions." J Chem Phys **141**(16): 164312.

It has been recently found [Gh. Galland, Y. Ghosh, A. Steinbruck, M. Sykora, J. A. Hollingsworth, and V. I. Klimov, Nature (London) 479, 203 (2011)] that semiconductor core/shell nanocrystals (NCs) with blinking photoluminescence (PL) can be of "A" or "B" type. NCs of A-type exhibit correlation between the intensity of PL and the life time. In NCs of B-type such correlation is absent. Simple model based on combination of the charging model and the two-level system model is proposed for describing emissive properties of NCs of both types. The model invokes fluctuations of emission ability gamma (em) of NC to explain the emissive properties of NCs of B-type. Our combined model is also in agreement with anticorrelation between the duration tau (off) of off intervals and PL life time t (off) in off intervals found recently for NCs of A-type in the experiment [A. A. Cordones, T. J. Bixby, and S. R. Leone, Nano Lett. 11, 3366 (2011)].

Poccia, N., et al. (2011). "Far from equilibrium percolation, stochastic and shape resonances in the physics of life." Int J Mol Sci **12**(10): 6810-6833.

Key physical concepts, relevant for the cross-fertilization between condensed matter physics and the physics of life seen as a collective phenomenon in a system out-of-equilibrium, are discussed. The onset of life can be driven by: (a) the critical fluctuations at the protonic percolation threshold in membrane transport; (b) the stochastic resonance in biological systems, a mechanism that can exploit external and self-generated noise in order to gain efficiency in signal processing; and (c) the shape resonance (or Fano resonance or Feshbach resonance) in the association and dissociation processes of bio-molecules (a quantum mechanism that could play a key role to establish a macroscopic quantum coherence in the cell).

Poccia, N. and A. Bianconi (2011). "The Physics of Life and Quantum Complex Matter: A Case of Cross-Fertilization." Life (Basel) **1**(1): 3-6.

Progress in the science of complexity, from the Big Bang to the coming of humankind, from chemistry and biology to geosciences and medicine, and from materials engineering to energy sciences, is leading to a shift of paradigm in the physical sciences. The focus is on the understanding of the non-equilibrium process in fine tuned systems. Quantum complex materials such as high temperature superconductors and living matter are both non-equilibrium and fine tuned systems. These topics have been subbjects of scientific discussion in the Rome Symposium on the "Quantum Physics of Living Matter".

Ravera, E., et al. (2017). "Perspectives on paramagnetic NMR from a life sciences infrastructure." J Magn Reson **282**: 154-169.

The effects arising in NMR spectroscopy because of the presence of unpaired electrons, collectively referred to as "paramagnetic NMR" have attracted increasing attention over the last decades. From the standpoint of the structural and mechanistic biology, paramagnetic NMR provides long range restraints that can be used to assess the accuracy of crystal structures in solution and to improve them by simultaneous refinements through NMR and X-ray data. These restraints also provide information on structure rearrangements and conformational variability in biomolecular systems. Theoretical improvements in quantum chemistry calculations can nowadays allow for accurate calculations of the paramagnetic data from a molecular structural model, thus providing a tool to refine the metal coordination environment by matching the paramagnetic effects observed far away from the metal. Furthermore, the availability of an improved technology (higher fields and faster magic angle spinning) has promoted paramagnetic NMR applications in the fast-growing area of biomolecular solid-state NMR. Major improvements in dynamic nuclear polarization have been recently achieved, especially through the exploitation of the Overhauser effect occurring through the contact-driven relaxation mechanism: the very large enhancement of the (13)C signal observed in a variety of liquid organic compounds at high fields is expected to open up new perspectives for applications of solution NMR.

Rimola, A., et al. (2009). "Formation versus hydrolysis of the peptide bond from a quantum-mechanical viewpoint: The role of mineral surfaces and implications for the origin of life." Int J Mol Sci **10**(3): 746-760.

The condensation (polymerization by water elimination) of molecular building blocks to yield the first active biopolymers (e.g. of amino acids to form peptides) during primitive Earth is an intriguing question that nowadays still remains open since these processes are thermodynamically disfavoured in highly dilute water solutions. In the present contribution, formation and hydrolysis of glycine oligopeptides occurring on a cluster model of sanidine feldspar (001) surface have been simulated by quantum mechanical methods. Results indicate that the catalytic interplay between Lewis and Bronsted sites both present at the sanidine surface, in cooperation with the London forces acting between the biomolecules and the inorganic surface, plays a crucial role to: i) favour the condensation of glycine to yield oligopeptides as reaction products; ii) inhibit the hydrolysis of the newly formed oligopeptides. Both facts suggest that mineral surfaces may have helped in catalyzing, stabilizing and protecting from hydration the oligopeptides formed in the prebiotic era.

Rohrmuller, M., et al. (2015). "The Cu2O2 torture track for a real-life system: [Cu2(btmgp)2O2] (2+) oxo and peroxo species in density functional calculations." J Comput Chem **36**(22): 1672-1685.

Density functional theory (DFT) calculations of the equilibrium geometry, vibrational modes, ionization energies, electron affinities, and optical response of [Cu2(btmgp)2(mu-O)2] (2+) (oxo) and [Cu2(btmgp)2(mu-eta (2):eta (2)-O2)] (2+) (peroxo) are presented. Comprehensive benchmarking shows that the description of the oxo-peroxo energetics is still a torture track for DFT, but finds the molecular geometry to be comparatively robust with respect to changes in the exchange-correlation functionals and basis sets. Pure functionals favor the oxo core found experimentally, whereas hybrid functionals shift the bias toward the peroxo core. Further stabilization of peroxo core results from relaxing the spin degrees of freedom using the broken-symmetry (BS) approach. Dispersion effects, conversely, tend to favor the oxo configuration. Triple-zeta basis sets are found to represent a sensible compromise between numerical accuracy and computational effort. Particular attention is paid to the modification of the electronic structure, optical transitions, and excited-state energies along the transition path between the oxo and peroxo species. The excited-state potential energy surface calculations indicate that two triplet states are involved in the transition that stabilize the BS solution. Charge decomposition and natural transition orbital analyses are used for obtaining microscopic insight into the molecular orbital interactions. Here, the crucial role of guanidine pi-interactions is highlighted for the stabilization of the Cu2O2 core.

Rosenberg, L. (2015). "The Associations Between Executive Functions' Capacities, Performance Process Skills, and Dimensions of Participation in Activities of Daily Life Among Children of Elementary School Age." Appl Neuropsychol Child **4**(3): 148-156.

Effective executive functions (EFs) are crucial for efficient daily functioning. Daily functioning or involvement in life situations is defined as "participation" (International Classification of Functioning, Disability, and Health [ICF]; World Health Organization, 2001). Yet associations between them have been inadequately studied for children. The present study aimed to explore the associations between EFs and child participation. Participants were 60 typically developing children aged 6 to 9 years old and their parents. The children were individually

evaluated using five EF cognitive tests. The parents completed three questionnaires: the Children Participation Questionnaire, the Process Skills (the observed executive performance) Questionnaire, and the Environmental Restrictions Questionnaire. Most of the EF scores were associated with the child's age. A unique contribution of executive capacities was found for the "independence" aspect of child participation, though the quantum of contribution was limited compared with the other predictors' process skills and environmental restrictions. In the context of child participation, EFs should be studied through multivariate analysis, as otherwise, the unique contribution of executive capacities measured by neuropsychological cognitive tests are likely to be ignored. Process skills are crucial for a child's independence and autonomy in daily functioning. These findings are supported by the capacity-performance distinction suggested by the ICF model.

Senger, H. (1970). "[Quantum yield and variable behavior of the two photosystems of the photosynthetic apparatus during the life cycle of Scenedesmus obliquus in synchronous cultures]." Planta **92**(4): 327-346.

Cultures of Scenedesmus obliquus strain D3 synchronized in a light-dark regime of 14:10 hours were used for studies of the photosynthetic activity during the life cycle of the organism. The quantum yield measured throughout the life cycle follows closely the photosynthetic capacity, with a maximum at the 8th and a minimum at the 16th hour in cells whose life cycle was initiated with the beginning of the light period. The amount of photosystem II activity (measured as p-benzoquinone Hill-reaction) and the action spectra demonstrate the same decrease from the 8th to the 16th hour as quantum yield does. However, the reaction of photosystem I seems to be the same throughout the life cycle, when measured as photoreduction or as a part of the light induced absorption change at 520 nm. With support from the observation that the Emerson-enhancement effect is highest at the 8th and lowest at the 16th hour of the life cycle, it was concluded that the two photosystems work with highest activity and in pace at the 8th hour. At the 16th hour the activity of photosystem I remains constant. Since cyclic photophosphorylation is higher at the 16th than at the 8th hour, it is suggested that the capacity of photosystem I, which is freed from photosystem II by a decreased electron flow, is used for additional cyclic photophosphorylation.

Shanta, B. N. (2015). "Life and consciousness - The Vedantic view." Commun Integr Biol **8**(5): e1085138.

In the past, philosophers, scientists, and even the general opinion, had no problem in accepting the existence of consciousness in the same way as the existence of the physical world. After the advent of Newtonian mechanics, science embraced a complete materialistic conception about reality. Scientists started proposing hypotheses like abiogenesis (origin of first life from accumulation of atoms and molecules) and the Big Bang theory (the explosion theory for explaining the origin of universe). How the universe came to be what it is now is a key philosophical question. The hypothesis that it came from Nothing (as proposed by Stephen Hawking, among others), proves to be dissembling, since the quantum vacuum can hardly be considered a void. In modern science, it is generally assumed that matter existed before the universe came to be. Modern science hypothesizes that the manifestation of life on Earth is nothing but a mere increment in the complexity of matter - and hence is an outcome of evolution of matter (chemical evolution) following the Big Bang. After the manifestation of life, modern science believed that chemical evolution transformed itself into biological evolution, which then had caused the entire biodiversity on our planet. The ontological view of the organism as a complex machine presumes life as just a chance occurrence, without any inner purpose. This approach in science leaves no room for the subjective aspect of consciousness in its attempt to know the world as the relationships among forces, atoms, and molecules. On the other hand, the Vedantic view states that the origin of everything material and nonmaterial is sentient and absolute (unconditioned). Thus, sentient life is primitive and reproductive of itself - omne vivum ex vivo - life comes from life. This is the scientifically verified law of experience. Life is essentially cognitive and conscious. And, consciousness, which is fundamental, manifests itself in the gradational forms of all sentient and insentient nature. In contrast to the idea of objective evolution of bodies, as envisioned by Darwin and followers, Vedanta advocates the idea of subjective evolution of consciousness as the developing principle of the world. In this paper, an attempt has been made to highlight a few relevant developments supporting a sentient view of life in scientific research, which has caused a paradigm shift in our understanding of life and its origin.

Shavro, S. A., et al. (2012). "Correlation of health-related quality of life with other disease severity indices in Indian chronic obstructive pulmonary disease patients." Int J Chron Obstruct Pulmon Dis **7**: 291-296.

BACKGROUND: Improvement in quality of life (QOL) has become a focus for the management of

incurable chronic diseases, including chronic obstructive pulmonary disease (COPD). This study investigates factors influencing the QOL of patients with COPD in India. METHODS: Seventy-three consecutive COPD patients visiting an outpatient pulmonary clinic underwent health-related QOL (HRQOL) assessment using the World Health Organization's QOL abbreviated questionnaire and St George's Respiratory Questionnaire (SGRQ). Symptom severity and grade of dyspnea were estimated by the Chronic Lung Disease Severity Index (CLD) and Medical Research Council assessments, and patient demographic data were collected. Spirometry and 6-minute walk tests were performed to assess lung function and functional status. RESULTS: Patients with COPD showed significantly reduced HRQOL when measured by the World Health Organization's QOL abbreviated questionnaire and the SGRQ. CLD estimate for severity of lung disease ($P < 0.001$), Medical Research Council assessment for dyspnea ($P < 0.01$), and duration of illness ($P < 0.05$) showed close correlation with HRQOL. Worsening forced expiratory volume in 1 second and 6-minute walk test results closely correlated with poorer HRQOL ($P < 0.01$). No association between QOL and age, quantum of smoking, education, comorbid illnesses, or occupational exposure was found. CONCLUSION: This study showed that Indian patients with COPD had reduced HRQOL. Longer disease duration, patient perception of disease severity, and worsening dyspnea impacted negatively on HRQOL.

Shojaie, F. and M. Dehestani (2010). "The simulation of virus life cycle with quantum gates." Comput Biol Med **40**(3): 359-362.

Quantum physics and molecular biology are two disciplines that have evolved relatively independently. However, recently a wealth of evidence has demonstrated the importance of quantum mechanics for biological systems and thus a new field of quantum biology is emerging. There are many claims that quantum mechanics plays a key role in the origin and/or operation of biological organisms. We consider the nucleonic acid of virus as a quantum system in this paper and discuss virus life cycle from the view-point of quantum and simulate it using quantum gates for the first time. The maximally entangled states show infected cell can change to entire cell, the virus can switch from the lysogenic to the lytic and the prophages can remain latent in the bacterial chromosome for many generations.

Sreenivasan, V. K., et al. (2013). "Luminescent nanoparticles and their applications in the life sciences." J Phys Condens Matter **25**(19): 194101.

Nanoparticles have recently emerged as an important group of materials used in numerous disciplines within the life sciences, ranging from basic biophysical research to clinical therapeutics. Luminescent nanoparticles make excellent optical bioprobes significantly extending the capabilities of alternative fluorophores such as organic dyes and genetically engineered fluorescent proteins. Their advantages include excellent photostability, tunable and narrow spectra, controllable size, resilience to environmental conditions such as pH and temperature, combined with a large surface for anchoring targeting biomolecules. Some types of nanoparticles provide enhanced detection contrast due to their long emission lifetime and/or luminescence wavelength blue-shift (anti-Stokes) due to energy upconversion. This topical review focuses on four key types of luminescent nanoparticles whose emission is governed by different photophysics. We discuss the origin and characteristics of optical absorption and emission in these nanoparticles and give a brief account of synthesis and surface modification procedures. We also introduce some of their applications with opportunities for further development, which could be appreciated by the physics-trained readership.

Takayanagi, T. (2017). "Nonadiabatic quantum dynamics calculations of transition state spectroscopy of I + HI and I + DI reactions: the existence of long life vibrational bonding resonances." Phys Chem Chem Phys **19**(43): 29125-29133.

We present the results of nonadiabatic quantum wave packet calculations to analyze the experimental transition state spectra for the I ((2)P3/2,1/2) + XI (X = H and D) hydrogen exchange reactions based on photodetachment of the IXI (-) anion. We developed (3 x 3) diabatic potential energy surfaces that can reasonably describe the nonadiabatic transitions induced by spin-orbit interactions. A good agreement was obtained between theory and experiment and it was found that nonadiabatic transitions play a role in the reaction dynamics. We also found that the calculated spectra showed very sharp resonance states with a vibrational bonding character, where the resonance wavefunctions are highly localized around the transition state region. Our calculated results suggest that one may experimentally detect these vibrational bonding resonances using time-domain transition state spectroscopy techniques since those states have picosecond-order lifetimes.

Tamulis, A. and M. Grigalavicius (2011). "The emergence and evolution of life in a "fatty acid world" based on quantum mechanics." Orig Life Evol Biosph **41**(1): 51-71.

Quantum mechanical based electron correlation interactions among molecules are the source of the weak hydrogen and Van der Waals bonds that are critical to the self-assembly of artificial fatty acid micelles. Life on Earth or elsewhere could have emerged in the form of self-reproducing photoactive fatty acid micelles, which gradually evolved into nucleotide-containing micelles due to the enhanced ability of nucleotide-coupled sensitizer molecules to absorb visible light. Comparison of the calculated absorption spectra of micelles with and without nucleotides confirmed this idea and supports the idea of the emergence and evolution of nucleotides in minimal cells of a so-called Fatty Acid World. Furthermore, the nucleotide-caused wavelength shift and broadening of the absorption pattern potentially gives these molecules an additional valuable role, other than a purely genetic one in the early stages of the development of life. From the information theory point of view, the nucleotide sequences in such micelles carry positional information providing better electron transport along the nucleotide-sensitizer chain and, in addition, providing complimentary copies of that information for the next generation. Nucleotide sequences, which in the first period of evolution of fatty acid molecules were useful just for better absorbance of the light in the longer wavelength region, later in the PNA or RNA World, took on the role of genetic information storage.

Tan, C. Y., et al. (2002). "[Application of quantum dot to life science]." Sheng Wu Hua Xue Yu Sheng Wu Wu Li Xue Bao (Shanghai) **34**(1): 1-5.

As an eminent representation of nanotechnology, quantum dot (semiconductor nanocrystal) has caught great interests of scientists in physics, chemistry, material science, and biology extensively. Although its application to life science has just been explored, valuable progresses have been achieved in both biomacromolecule labeling and coding recently. The progress in quantum dot synthesis, its spectroscopic and photoelectronic properties, and its potential application to life science are reviewed.

Trevors, J. T. (2006). "The Big Bang, Superstring Theory and the origin of life on the Earth." Theory Biosci **124**(3-4): 403-412.

This article examines the origin of life on Earth and its connection to the Superstring Theory, that attempts to explain all phenomena in the universe (Theory of Everything) and unify the four known forces and relativity and quantum theory. The four forces of gravity, electro-magnetism, strong and weak nuclear were all present and necessary for the origin of life on the Earth. It was the separation of the unified force into four singular forces that allowed the origin of life.

Trevors, J. T. (2011). "Origin of microbial life: Nano- and molecular events, thermodynamics/entropy, quantum mechanisms and genetic instructions." J Microbiol Methods **84**(3): 492-495.

Currently, there are no agreed upon mechanisms and supporting evidence for the origin of the first microbial cells on the Earth. However, some hypotheses have been proposed with minimal supporting evidence and experimentation/observations. The approach taken in this article is that life originated at the nano- and molecular levels of biological organization, using quantum mechanic principles that became manifested as classical microbial cell (s), allowing the origin of microbial life on the Earth with a core or minimal, organic, genetic code containing the correct instructions for cell (s) for growth and division, in a micron dimension environment, with a local entropy range conducive to life (present about 4 billion years ago), and obeying the laws of thermodynamics. An integrated approach that explores all encompassing factors necessary for the origin of life, may bring forth plausible hypotheses (and mechanisms) with much needed supporting experimentation and observations for an origin of life theory.

Trixler, F. (2013). "Quantum Tunnelling to the Origin and Evolution of Life." Curr Org Chem **17**(16): 1758-1770.

Quantum tunnelling is a phenomenon which becomes relevant at the nanoscale and below. It is a paradox from the classical point of view as it enables elementary particles and atoms to permeate an energetic barrier without the need for sufficient energy to overcome it. Tunnelling might seem to be an exotic process only important for special physical effects and applications such as the Tunnel Diode, Scanning Tunnelling Microscopy (electron tunnelling) or Near-field Optical Microscopy operating in photon tunnelling mode. However, this review demonstrates that tunnelling can do far more, being of vital importance for life: physical and chemical processes which are crucial in theories about the origin and evolution of life can be traced directly back to the effects of quantum tunnelling. These processes include the chemical evolution in stellar interiors and within the cold interstellar medium, prebiotic chemistry in the atmosphere and subsurface of planetary bodies, planetary habitability via insolation and geothermal heat as well as the function of biomolecular nanomachines. This review shows that quantum tunnelling has many highly important implications to

the field of molecular and biological evolution, prebiotic chemistry and astrobiology.

van Mourik, T. (2004). "First-principles quantum chemistry in the life sciences." Philos Trans A Math Phys Eng Sci **362**(1825): 2653-2670.

The area of computational quantum chemistry, which applies the principles of quantum mechanics to molecular and condensed systems, has developed drastically over the last decades, due to both increased computer power and the efficient implementation of quantum chemical methods in readily available computer programs. Because of this, accurate computational techniques can now be applied to much larger systems than before, bringing the area of biochemistry within the scope of electronic-structure quantum chemical methods. The rapid pace of progress of quantum chemistry makes it a very exciting research field; calculations that are too computationally expensive today may be feasible in a few months' time! This article reviews the current application of 'first-principles' quantum chemistry in biochemical and life sciences research, and discusses its future potential. The current capability of first-principles quantum chemistry is illustrated in a brief examination of computational studies on neurotransmitters, helical peptides, and DNA complexes.

Vanzi, M., et al. (2000). "Electron microscopy of life-tested semiconductor laser diodes." Micron **31**(3): 259-267.

Electron Microscopy on life-tested 980 nm SL SQW InGaAs/AlGaAs laser diodes is able to find and analyze lattice defects responsible for the detected failures. Anyway, the origin and evolution of those defects remains questionable. Only the comparative analysis of life-test measurements, EBIC-FIB/TEM images, and charge-transport physics is able to point out a coherent framework for complete decoding of the failure kinetics. Minority-carrier diffusion and their enhanced recombination at defective lattice points are indicated, as the energy supply required for defect reaction and growth. The rules of charge diffusion drive both the reaction model, the interpretation of EBIC images and the expected electrical and optical effects. Strain release at the ultimate propagation of defects into the strained InGaAs quantum layer is then easily related to the final state of the failed devices.

Ventegodt, S., et al. (2003). "Quality of life philosophy IV. The brain and consciousness." ScientificWorldJournal **3**: 1199-1209.

In this article we look at the brain's structure and function from a philosophical perspective. Although the brain at micro-level, with its trillions of ultra-thin nerve fibers, is one of the most complicated structures in the known universe, you can still grasp its composition if you go up to the level of the cell. How this structure functions is not quite clear. You can understand its function at fiber level, because it is fairly simple, and you can understand it at cell level, but it is already vague. Roughly speaking, you can envision a single nerve cell as a tiny, independent computer whose behavior is dependent on continuous calculations of all input. At organ level, the function can be understood as an extremely complex pattern machine. Finally, the brain"s function can be understood at the cognitive level as what provides consciousness through its ability to keep order in our complicated reality. The superior function of the brain is to connect the real us, our higher self, to the surrounding world. The brain has been developed so that it can create all possible complex patterns. The connectivity seems to imply that the patterns of the human brain are 1000-dimensional. It is our vision that these complicated patterns arise from basic patterns in the quantum matter of which everything is created. In our opinion, our consciousness" special utilization of a patterned aspect of nature is what lies behind inscrutable statements like "Man is created in God"s image". We suggest that these patterns in matter are the basic, creative force that influences all living organisms. Unfortunately, science has only just begun to understand these patterns. The Bible's description of the origin of man is two people eating from the Tree of Knowledge and as punishment they are expelled from the Garden of Eden. What does that mean? It means that, as conscious creatures, we no longer were an unproblematic, harmonious part of the world around us. The great question is why this consciousness about the world, provided by the brain, is not a gift that makes life better instead of getting us expelled from the Garden of Eden. We think that our real problem is the fact that we are still not in control of our consciousness. Instead of it serving us, we have become its slaves. If we come to understand brain and consciousness in order to solve this basic problem of our existence, we shall again be able to become a coherent part of the world, both as individuals and as a species. We share the vision that such an understanding of the problems of consciousness will make medical science holistic and will bring quality of life, health, and the ability to function to its patients.

Ventegodt, S., et al. (2006). "Human development II: we need an integrated theory for matter, life and consciousness to understand life and healing." ScientificWorldJournal **6**: 760-766.

For almost a decade, we have experimented with supporting the philosophical development of severely ill patients to induce recovery and spontaneous

healing. Recently, we have observed a new pattern of extremely rapid, spontaneous healing that apparently can facilitate even the spontaneous remission of cancer and the spontaneous recovery of mental diseases like schizophrenia and borderline schizophrenia. Our working hypothesis is that the accelerated healing is a function of the patient's brain-mind and body-mind coming closer together due to the development of what we call "deep" cosmology. To understand and describe what happens at a biological level, we have suggested naming the process adult human metamorphosis, a possibility that is opened by the human genome showing full generic equipment for metamorphosis. To understand the mechanistic details in the complicated interaction between consciousness and biology, we need an adequate theory for biological information. In a series of papers, we propose what we call "holistic biology for holistic medicine". We suggest that a relatively simple model based on interacting wholenesses instead of isolated parts can shed a new light on a number of difficult issues that we need to explain and understand in biology and medicine in order to understand and use metamorphosis in the holistic medical clinic. We aim to give a holistic theoretical interpretation of biological phenomena at large, morphogenesis, evolution, immune system regulation (self-nonself discrimination), brain function, consciousness, and health in particular. We start at the most fundamental problem: what is biological information at the subcellular, cellular, and supracellular levels if we presume that it is the same phenomenon on all levels (using Occam's razor), and how can this be described scientifically? The problems we address are all connected to the information flow in the functioning, living organism: function of the brain and consciousness, the regulations of the immune system and cell growth, the dynamics of health and disease. We suggest that life utilizes an unseen fine structure of the physical energy of the universe at a subparticular or quantum level to give information-directed self-organization; we give a first sketch of a possible fractal structure of the energy able to both contain and communicate biological information and carry individual and collective consciousness. Finally, thorough our analysis, we put up a model for adult human metamorphosis.

Vinogradov, A. E. and O. V. Anatskaya (2004). "Phenological resonance and quantum life history." J Theor Biol **228**(3): 417-420.

The principle of 'quantum life history' is proposed here as a complementary viewpoint to current modeling of body size and life history evolution which usually considers a 'fast-slow continuum' of covarying life history traits. This principle emphasizes the discrete (and primary) nature of development time caused by the effect of phenological resonance (the compliance of development time with periodicities of earth rotation). The body mass, in turn, complies with development time, which generates body mass attractors. This principle is illustrated with mammals as exemplary group. The adaptive radiation of Cenozoic mammals is supposed to proceed as a competition-driven diversification of body sizes and development times around the strongest (year-long) resonant mode of development time corresponding to body mass of about 1 kg. Mammals with this body mass are shown here to have a largest genome size and a lowest (body mass-corrected) basal metabolic rate. This extends the previously reported negative relation between genome size and metabolic rate to the realm of nonlinearity, and suggests that selection against the accumulation of non-coding DNA in the genome is relaxed in mammals with this body mass.

Vladilo, G. and A. Hassanali (2018). "Hydrogen Bonds and Life in the Universe." Life (Basel) **8**(1).

The scientific community is allocating more and more resources to space missions and astronomical observations dedicated to the search for life beyond Earth. This experimental endeavor needs to be backed by a theoretical framework aimed at defining universal criteria for the existence of life. With this aim in mind, we have explored which chemical and physical properties should be expected for life possibly different from the terrestrial one, but similarly sustained by genetic and catalytic molecules. We show that functional molecules performing genetic and catalytic tasks must feature a hierarchy of chemical interactions operating in distinct energy bands. Of all known chemical bonds and forces, only hydrogen bonds are able to mediate the directional interactions of lower energy that are needed for the operation of genetic and catalytic tasks. For this reason and because of the unique quantum properties of hydrogen bonding, the functional molecules involved in life processes are predicted to have extensive hydrogen-bonding capabilities. A molecular medium generating a hydrogen-bond network is probably essential to support the activity of the functional molecules. These hydrogen-bond requirements constrain the viability of hypothetical biochemistries alternative to the terrestrial one, provide thermal limits to life molecular processes, and offer a conceptual framework to define a transition from a "covalent-bond stage" to a "hydrogen-bond stage" in prebiotic chemistry.

Zhelev, Z., et al. (2004). "Enhancement of the photoluminescence of CdSe quantum dots during long-term UV-irradiation: privilege or fault in life

science research?" J Photochem Photobiol B **75**(1-2): 99-105.

The present study describes an impressive enhancement of the photoluminescence (PL) intensity of low-temperature synthesized CdSe nanocrystals (75 degrees C) during long-term UV-irradiation. The integrated PL-intensity of CdSe core and CdSe/ZnS core/shell nanocrystals, dispersed in chloroform, enhanced about 3 and 6 times, respectively, during 9 h exposure to UV-light, without any significant changes in the characteristic absorbance spectra and shifting of PL-spectra. After termination of the irradiation a comparatively slow photobleaching was detected with tau (1/2) = 6 h for CdSe core and tau (1/2) = 14 h for CdSe/ZnS core/shell nanocrystals. The most impressive was the effect of UV-irradiation on the photoluminescence of water-soluble CdSe nanocrystals. The integrated PL-intensity enhanced about 10 times during 11 h exposure to UV-light and the improved PL-intensity was preserved during 3 days after termination of the irradiation without any significant photobleaching. The results are discussed in the context of application of CdSe nanocrystals as novel fluorophores in life science experiments.

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